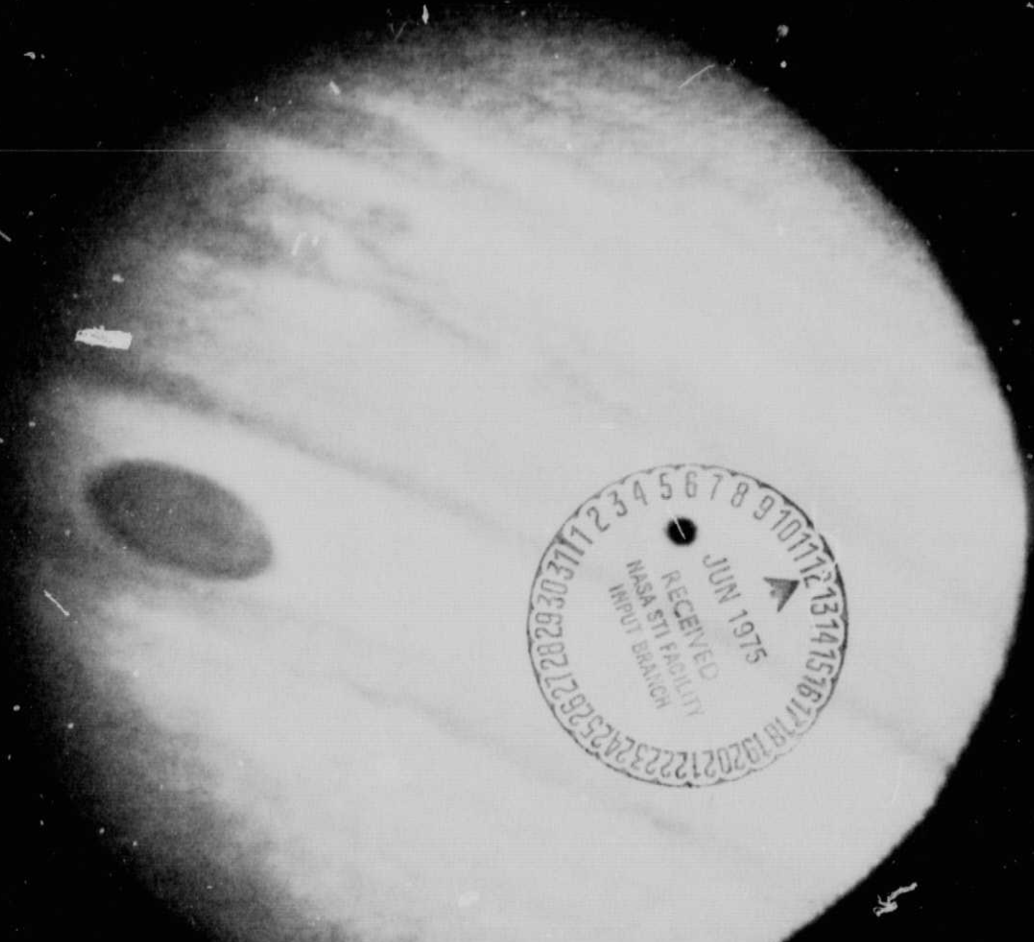
THE NOW FRONTIER

MAN LINKS EARTH AND PLANETS

PIONEER TO JUPITER



ISSUE NUMBER THREE
JUPITER AND PLANET EARTH

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The question of beginnings has always intrigued people. How did something appear from nothing? All civilizations have tried to guess how the Universe, the Earth, and people originated. Early people thought everything was born from a universal mother. Today, steeped in the nuclear age, scientists suggest everything came from a big bang, a universal atomic bomb, about 13 billion years ago. Stars and their planets later condensed from the clouds of gas (hydrogen) that resulted from the creative explosion.

We are still far from having satisfactory answers as to how something (the universe) was created from nothing (the void) and even as to how the Solar System condensed from electrified atoms, darting molecules, and intertwining forces of some primeval mass of gas (nebula). How did the various planets evolve their unique characteristics? How did life blossom here on Earth?

It is not easy to find answers on Earth since this planet can be studied only in its present stage of evolution, a single frame in the long motion picture of Earth. And the single picture does not provide enough information for scientists to be sure about the past let alone Earth's probable future. However, other planets may pass through evolutionary history at different rates—some may be ahead, others lag behind Earth. So if these other planets are studied at close hand, by space probes rather than remotely by astronomical telescopes, they provide clues about Earth's history, development of natural resources, changes in atmosphere and their effects upon life processes, and expected evolution.

Knowledge about the other planets is important to our understanding Earth's past and future and is vital to the long-term survival of the human species if people are to adapt to inevitable natural and man-made changes to Earth's environment.

In many respects Jupiter models what takes place in the universe at large. Many processes on Jupiter are similar to those in a star (or the Sun) before its nuclear fire ignites. And the great turmoil of Jupiter's processes, coupled with high speed of rotation on its axis, provides a model for the study of jet streams and weather in the Earth's relatively quiet atmosphere.

Jupiter may also represent a stage paralleling an early period of Earth—the stage when life began to form here. In fact, Jupiter may be more favorable to life than any other planet, not excepting Earth.

And the circling satellites of Jupiter are a veritable Solar System in miniature. Their formation may have paralleled the formation of the Solar System itself.

EVOLUTION OF PLANETS

Planets of the Solar System probably formed four to five billion years ago when hosts of small rocky particles and clouds of gases collected together by their own gravity. An idea can be gained of how long four billion years is by letting the thickness of this paper represent one year. Four billion years needs a stack of paper 200 miles high!

Gravity appears to be a universal property of matter as a result of which every particle, no matter how small, attracts every other. Thus, left to themselves in space, individual particles (and a gas also consists of particles) tend to collect together into large masses.

After the Sun itself condensed from a primeval nebula, planets of different sizes collected from different concentrations of matter present at various distances from the Sun. And electric and magnetic forces in the gas clouds probably thrust these condensing planets into orbits around the central Sun. If one planet started early it scooped up more matter than those starting later with less free material to collect. The oldest craters on Mars and craters on the Moon are thought to be evidence of the final stages of planetary accretion as this process is called (Figure One).

Much of the primeval gas was hydrogen—the most common material in the universe—which consists of a proton and a circling electron. The Sun, for example, is nearly all hydrogen, as are the stars. And astronomers have discovered vast clouds of hydrogen in the spaces between stars.

While it is most probable that the Earth as it formed was never able to pull to itself much hydrogen, it might have possessed some in its atmosphere for a short while. The closeness of the Earth to the Sun makes the Earth too warm to hold free hydrogen for long. Hydrogen escapes like steam bubbling from a hot saucepan. Most hydrogen remaining on Earth is locked with oxygen to form molecules of water—the Earth's oceans.

Similarly, the Moon, Mercury, Venus, and Mars cannot hold hydrogen. They would need to be much larger—have much stronger gravity—to prevent hydrogen 'boil-off' from heat due to their closeness to the Sun. But cooler Jupiter, 350 million miles beyond Mars, also has a strong gravity which holds hydrogen in tremendous quantities. So do the other large, distant planets: Saturn, Uranus, and Neptune.

Jupiter, if stripped of its hydrogen, might be a solid planet not much larger than the inner planets. So all the outer planets may really be inner-type planets surrounded by very deep atmospheres.

THE ATMOSPHERE

Knowledge about these complex atmospheres may help us to understand Earth's more simple atmosphere. Already the study of dust storms in Mars' very thin atmosphere is helping Earth's meteorologists.

At some level in the deep atmosphere of Jupiter—an atmosphere of hydrogen seasoned with helium, methane, ammonia, and water—the temperature should equal that on Earth. At this level ammonia crystals detected in Jupiter's cloud tops become liquid ammonia droplets. Water condenses, too. The droplets rain from the clouds, sometimes frozen into snows of water and ammonia. But the drops and the snowflakes could never fall to the surface as they do on Earth. Instead, at warm lower regions of the deep atmosphere, they again must evaporate and rise back into the clouds.

The circulation must cause endless violent turbulence in the Jovian atmosphere, more violent than any thunderstorms of Earth. And accompanying electrical discharges make Earth's lightning flashes mere sparks by comparison.

Thus the vertical movements in the atmosphere of Jupiter provide models of the most violent storms imaginable. At the same time the jet circulations in the cloud bands and zones, described in the second pamphlet of this series, compare to Earth's major atmospheric patterns, trade winds and jet streams.

Studies of the cloud patterns of Jupiter and their motions can help us understand how Earth's atmosphere circulates and how hurri-

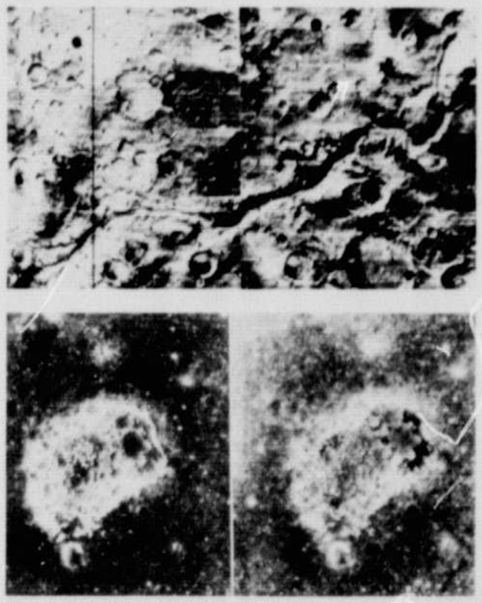

Figure 1. Craters on Mars (top photo) and Moon (bottom photo),

canes and other disastrous weather systems originate. Perhaps we shall also find ways to control Earth's bad weather and prevent floods and wind damage.

RADIATION BELTS

Among the planets only Earth and Jupiter are known to have radiation belts (Figure Two), the result of strong magnetic fields whereby both planets behave like big magnets and trap charged particles from space. These particles, electrons and protons, race along lines of force produced by the magnetic field. (On Earth it is this same field that causes the needle of a magnetic compass to point toward the north.)

Jupiter's stronger magnetic field traps more particles. So its radiation belts extend 255,000 miles above the cloud tops (further than the distance from Earth to Moon) and contain at least 100 trillion times the energy of Earth's belts. Major questions are: why Jupiter's magnetic field is so strong compared with Earth's, and are the two fields caused the same way.

Radiation belts are important because their speeding particles can affect instruments carried by spacecraft and even upset control of a spacecraft. Many missions to explore the outer solar system require spacecraft to approach close to Jupiter to use its gravity as a slingshot. This considerably shortens the long times needed to reach, say, Neptune or Uranus. But if Jupiter's radiation belts damage spacecraft we cannot use this slingshot technique.

Radio waves tell us about the number of electrons in the belts. But it is the protons in the belts that are damaging. These can only be measured by carrying instruments into the belts. Pioneer 10 will do this early in December. Then we should know how much we can use Jupiter as a slingshot for subsequent missions to the outer planets as well as learn much more about radiation belts in general.

SATELLITES

Two satellites of Jupiter are as large as Mercury. They could possess atmospheres. Some satellites have odd characteristics. The close, large satellite, Io, normally a very bright world, is brighter still when it first emerges from Jupiter's shadow. Could this be frost or snow evaporating? If so, it would mean that the satellite has an atmosphere. Astronomers question whether these satellites have features of earth-like inner planets or are more like giant snowballs.

The four outermost small satellites, Andrastea, Pan, Poseidon, and Hades, move around Jupiter in a counter direction to most of the Jovian satellites. They could be captured asteroids.

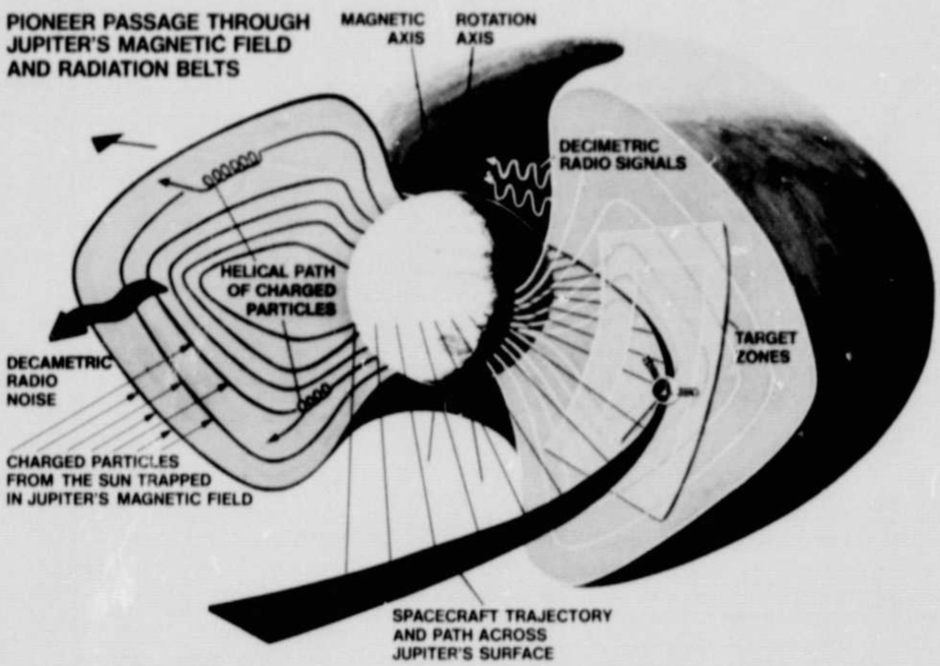

Figure 2. Jupiter's radiation belts (NASA picture).

Pioneer spacecraft will get close looks at the larger satellites and help to resolve current mysteries about them.

EVOLUTION OF LIFE

Life might be described as an unexplained force that somehow organizes inanimate matter into a living system that perceives, reacts to, and evolves to cope with, changes to the physical environment that threaten to destroy its organization.

In 1953 a mixture of hydrogen, methane, ammonia, and water vapor—the kind of atmosphere the Earth probably had soon after it was formed and the kind Jupiter has today—was treated in a laboratory. Scientists passed electrical discharges through the gas mixture to obtain the same effect as bolts of lightning. The result was surprising and important. The electrical energy changed some of the simple gases into more complex mixtures of carbon, hydrogen, nitrogen and oxygen, new molecules that we believe to be the essential building blocks for living systems.

We conclude that natural processes such as lightning and ultraviolet light from the Sun (the light that sunburns) can produce complex chemicals to form building blocks for living things. In fact, some of the complex chemicals are found in the space between the stars and on meteorites (the familiar 'falling stars'): small rocks that plunge into the Earth from outer space.

At some point in the past, probably about 3½ billion years ago, something organized the complex carbon-based molecules into living systems which were then able to make copies of themselves—to reproduce. From then on, by slight changes to subsequent copies, biological evolution produced all the living creatures of Earth. And at one stage a special consciousness appeared that gave rise to Man himself (Figure Three).

A big question is whether life has evolved in this way in the atmosphere of Jupiter. It is known that temperatures could be right. It is known that the gas mixture is right. It is known that electrical discharges take place. Studies of the Great Red Spot suggest it may be rich in amino acids, an important stage in building the living cell which is the simplest form of life.

While the Pioneer spacecraft is not designed to answer directly the question of life on Jupiter or its satellites (we would need a spacecraft to enter the atmosphere of Jupiter), these spacecraft will add considerably to knowledge about the physical processes taking place in Jupiter's atmosphere. They should also provide close looks at some of the big satellites. Thus these Pioneers will contribute to a better understanding of whether or not life could exist in the Jovian system.

Jupiter may, indeed, hold keys not only to the origin of life but also to secrets of the stars, for Jupiter is almost big enough to be a star in the making.

STUDY PROJECTS

ONE

Assuming that electrical discharges created living systems in Jupiter's atmosphere and that amino acids continually drift down from the clouds as food, a kind of "manna from heaven," use your imagination to draw the type of life that might have evolved. Remember that the atmosphere is very stormy with swift and furious winds and powerful currents so the life form would have to be able to move about quickly—wings, jets from gas bags? And would other life forms evolve as on Earth to prey on lesser creatures? Draw or paint a picture depicting life as it might be in the atmosphere of Jupiter.

TWO

Read astronomical textbooks and make three lists; a) those things on or about Jupiter that are similar to their counterparts on Earth, b) those that are different, and c) unanswered questions about Jupiter. Make notes on how further information about these similarities and differences and answers to the questions can aid in understanding Earth. When Pioneer 10 flies by Jupiter this December update your list and check off those unknowns which are then answered.

READING LIST

Lawless, Folsome, and Kvenvolden, Scientific American, June 1972, (Organic Matter in Meteorites).

Frieden, Scientific American, July 1972, (The Chemical Elements of Life).

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TIME	GEOLOGIC ERA	LIVING SYSTEMS EVOLVE	EARTH CHANGES
PRESENT		MAN (CONSCIOUSNESS)	ICE AGE (MOST RECENT)
	CENOZOIC		
	MESOZOIC	FIRST MAMMALS	
	PALEOZOIC	CREATURES WITH SPINES	CLOSE TO PRESENT DAY ATMOSPHERE
1000		FIRST MULTI-CELLED CREATURES	
2000			OXYGEN INCREASES
MILLIONS OF YEARS	PRE-CAMBRIAN		
3000			ATMOSPHERE ENRICHED WITH OXYGEN BY ALGAE
		FIRST MICROFOSSILS (ALGAE, BACTERIA)	ATMOSPHERE WATER, METHANE, AMMONIA, AND POSSIBLY HYDROGEN
4000		EVOLUTION OF CARBON COMPOUNDS (THE BUILDING BLOCKS OF LIVING SYSTEMS)	A CRUST AND WATER OCEANS
	EARTH FORMATION	TOO HOT AND CHAOTIC FOR LIVING SYSTEMS	AN EARTH SPHERE FORMS
5000			PARTICLES GASES A FORMLESS VOID

Figure 3. The evolution of living systems.